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VIII.—*An Account of the Germination of* Isoëtes lacustris. By Karl Müller*.

[With two Plates.]

1. *Introduction.*

M. A. Raffenau Delile has already contributed an essay on this subject. He observed the germination of this very interesting genus in *Isoëtes setacea*. His observations were published in the 'Mémoires du Muséum d'Histoire Nat. de Paris,' tom. xiv. p. 100 *et seq.*, accompanied by two plates. However the whole of his investigations throw but little light upon the matter if we look especially—and with reason—for an account of the development of the embryo. M. Delile has given scarcely more than what may be observed with the naked eye in every germinating *Isoëtes*: the germ breaking through the ovule and developing independently.

It therefore was exceedingly agreeable to me, when my friend Dr. Karl Jessen of Kiel, through the kindness of Prof. Kunze of Leipsic, sent me for minute examination a quantity of *Isoëtes lacustris* with beautifully developed reproductive bodies. I was the more desirous of obtaining these from having recently studied the germination of the *Selaginellæ*, and had reason to expect that the two genera would exhibit as much agreement in this point as they do in their other allied conditions, depending on the structure of the two kinds of reproductive organs. How far this has turned out to be true will be seen in the course of these investigations. In any case it was of great scientific interest to make out the relation of two plants—as to the natural affinity of which opinion varies so much—in their earliest development, so

* Translated by Arthur Henfrey, F.L.S., from the Botanische Zeitung, April 14 and 21, 1848.

that some conclusion might be drawn as to the degree of their relationship.

The second reason which especially attracted me to the investigation of this subject was the peculiarity of the root-stock, first observed and described by H. v. Mohl, on which the youngest roots, contrary to the custom in all other vascular plants, develope out of the centre of the stem in a deep furrow, while the rootlets occurring on the outer periphery of the root-stock are the very oldest. It might be expected that the history of the development would give some information as to this circumstance; indeed it must be admitted that without a thorough knowledge of it, no safe opinion can be formed of the nature of the matter. Whether the following complete account of the development up to a tolerably perfect condition of the germ is sufficient for the above purpose, will subsequently be seen.

There was yet a third reason which rendered the whole investigation highly desirable to me; namely the wish to examine how the earliest formation of the embryo took place in an *asexual* plant, how it was brought about. It will be readily conceded here also, that this parallel is extremely well fitted to throw light upon the formation of the embryo in both classes of plants. Whether and how far the following history of development will allow of the parallel being perfectly drawn, will hereafter be evident in the course of the exposition. I think that at this moment we are in the utmost need of an investigation which shall show the—I might call it *uteral*—formation of the embryo in an asexual plant, where consequently there is no question about pollen-tubes. I think so the more that it will not be long before two parties stand opposed to each other, one ranged under the banner of Schleiden, the other of Amici. *Selaginella*, and still better *Isoëtes*, on account of the readier germination, perfectly admit of such an investigation, and the poor botanist who has looked around him so much for *analogies*, has really much reason to be earnestly thankful for the creation of the Lycopodiaceæ, for I know of no other family in which this again occurs.

These three reasons determined me to an investigation of a complete course of development of *Isoëtes lacustris*. I would willingly —as indeed I much wished—have given a further account of the whole course of development of this plant, but the air of the chamber affected all my hundreds of germinating plants, which I the more regret since my time is now too much taken up with other botanical matters to allow of my calculating on returning very soon to this subject. It was also part of my plan to add the earliest stages of the development of the *Selaginellæ*—which in my earlier researches I neglected, or rather did not discover. I lament that from the same causes I am unable to do so here, and therefore I beg the indulgent reader at least to follow with me the *germinating Isoëtes lacustris.*

2. *The Ovule.*

No explanation is necessary when I name the spore propagating the species an *ovule.* I have already used this expression in the same sense in my essay on the development of the Lycopodiaceæ*, for the germinating spore, and consequently also with Spring called the sporangium of *Selaginella* which incloses the spore of this kind, the *oophoridium.* The reasons why I then thought that I ought so to do were morphological and physiological, since the course of development of the oophoridium proved a distinct *axial* nature, and the plant, unlike the other vascular and cellular asexual vegetables, developed, not *extra* but *intra uterum.* This last reason is decidedly the more important here, and is fully applicable to *Isoëtes.* But whether the first ground is tenable in this genus may perhaps be doubted by many persons, who, with H. v. Mohl, would regard the germinating spore as a leaf-product. I regret especially in regard to this point that my history of the development does not extend up to this stage, for I do not for a moment doubt that the oophoridium of *Isoëtes* is equally an axial structure, and does not belong to the leaves as Mohl thinks. It is not of much importance that it is inclosed as in a sheath by the base of the leaf in *Isoëtes.* The leaves are so smooth all round that one may thence conclude that their bases are not applied to the formation of the oophoridia. The simpliest view of the matter is to assume that a mother-cell of the root-stock itself grows up into the excavated base of the leaf exactly as the mother-cell of the oophoridium does in *Selaginella*†. In bringing forward—and certainly with good reason—the condition of this latter plant as an analogical proof here, I think that I fully make good my view. It is evident then that the sporangia also of the spores which do not germinate are of an axial nature, as is the case in *Selaginella.* To complete the comparison between the ovule of the sexual plants and that of the Lycopodiaceæ, a third reason, an anatomical one, presents itself in *Isoëtes,* for the ovule of the *Isoëtes,* exactly like that of sexual plants, consists of three coats, to which may in a similar manner be applied the simple names *primine, secundine* and *nucleus,* without regarding the special anatomical distinctions.

1. The *Primine.*—This coat is not composed of cellular tissue.

* Ann. of Nat. Hist. Ser. 1. vol. xix.

† Ann. of Nat. Hist. Ser. 1. vol. xix. Pl. IV. fig. 7 *c* & fig. 9 *a.*

It is a dense envelope consisting of brown cellulose, which is covered on both surfaces, inside and out, with reticulated, ramifying ridges which give it the appearance of being composed of cellular tissue in which the cells only, but in their entire diameter, are homogeneously thickened (Pl. II. fig. 1). These ridges—by no means rare phænomena in the ovules of Lycopodiaceæ generally—have their analogues, like the whole primine, in the outer coat of the pollen-grains of many sexual plants. They usually project so much from the surface of the primine that they give the ovule a very wrinkled appearance. Indeed the conditions of their ramifications and elevations are so constant in the species of *Isoëtes*, that, recently, some new—and as Prof. Kunze thinks good—species have been discriminated by this character. On the surface of the primine here also, as in *Selaginella*, run the furrows of the tetrahedral union, appearing with more or less distinctness, in consequence of which the ovule itself exhibits a more or less perfect tetrahedral shape. At these furrows the primine subsequently splits in the germination (fig. 1).

2. The *Secundine*.—This has a wholly similar structure to the preceding, to the inner surface of which it is pretty firmly applied; but in germination it may very easily be isolated. Like the primine it is a thick brown coat produced by the deposition of cellulose, but it is quite homogeneous, and only exhibits here and there on the outer surface, impressions of those ridges which beset the primine. How these two membranes, each independently—as it appears—can be formed by the deposition of cellulose, will certainly remain a problem until the course of development of the oophoridia is known.

3. The *Nucleus*.—This forms a special, thick envelope, which is the more extraördinary that it is composed of a layer of broad, colourless, loosely united delicate cells, only here and there filled with uncoloured globules. When this layer of cells is examined on the outer surface, the form of the cells appears to be somewhat cubical with truncated angles (fig. 2). Almost all over the coat occur also other cells, essentially distinct from the delicate kind. These lie grouped round a centre. This consists of a very large cell which soon becomes divided into four by two septa crossing one another (figs. 2, 3). This large cell in many cases bears considerable resemblance to a stomate, but must not be imagined to be one. Yet it shares with many stomates the peculiarity, that it projects as a papilla from the surface. It is polyhedral, usually oval (fig. 3), but very often constricted in four places at the sides, so that the papillary projection appears to be composed of four spherical cells (fig. 2). All the walls of these large cells are excessively thickened on both sides, evidently by the deposition of cellulose. The thickening itself is emarginate on

both sides. Frequently also it passes over, the point running out, into the walls of the contiguous cells. All the cells of these remarkable groups are of a brown colour, which is deepest in the large cell, the colouring gradually fading outwards till it reaches the extremely delicate cellular tissue bounding the group; this tissue contrasting the more with the group that its walls are composed of much firmer and more distinctly defined membranes. Moreover the cells lying immediately round the large cell are distinguished by the irregularity of their form from those situated beyond them. Many such groups occur upon the coat of the nucleus. Frequently they are far apart, often near together, or again arranged in groups, so that we find no special regularity in the whole. But at one point the condition is more constant, for they especially occur upon that part of the surface of the coat where the primine and secundine subsequently open (fig. 1 *a*). At the point of the orifice usually appears one large cell (fig. 1 *a*) with its accessory cells, and it appears to me that it is exactly this place which subsequently gives way in the breaking through of the germ. It is conceivable that the coat is most brittle here, and therefore gives way so much the more readily when it is pushed up in a cone by the rising embryo. The presence of all these groups at the point of the ovule may be just as easily explained. I imagine that the thickening of this surface is merely to afford an additional defence to the contents of the nucleus and to the embryo against external, hurtful influences. For the bursting of the primine, which is always followed by that of the secundine, appears to depend upon various circumstances. Now if this dehiscence happened at an epoch when the contents of the nucleus had not yet attained to substantial independence sufficient to enable it to defend itself from the surrounding water, and the coat of the nucleus was yet so delicate that it would be powerless against the intrusion of any moisture, the conclusion is not very distant; certainly it would not be exactly beneficial to the contents of the nucleus. This seems to me to be the simplest, because the most natural explanation. The peculiar dehiscence of the primine and secundine also speak in favour of it. These two membranes only retract gradually during the process of germination, and remain attached to the nucleus until the embryo is very substantially developed, and all and every of the contents of the nucleus, which we shall presently become acquainted with, have disappeared. Where the root subsequently breaks through, those groups of cells do not make their appearance. By the time however that the breaking-through ensues, the young plant is already supplied with nutriment in a different way, as we shall discover in the course of this description; it is sufficiently independent to be able to defend itself against the water.

With regard to the coat of the nucleus, this appears to be called the spore-cell by some authors, for instance by Mettenius*. In the passage referred to, he describes the ovule of *Isoëtes lacustris* as follows :—" In *Isoëtes lacustris* the flattened surface of the large spore, which has the three ridges, is separated from the remainder of the periphery of the spore by an annular border, as has already been observed by Bischoff (Kryptog. Heft iii. p. 81), and the stratified composition of the outer coat, is still more evident than in *Lycopodium* (*Selaginella*). The spore-cell is immediately surrounded by a thin layer of membrane, then follows one tough and darker; both are of a granular structure; as the third and outermost layer succeeds one consisting of distinct pieces, readily separable, somewhat more transparent, and possessing papillose elevations on its surface." In numerous investigations I have found but the three coats which I have described above. The description of Mettenius is therefore obscure to me. Since he also describes three coats, I may guess that by the *spore-cell* he means my third coat, the nucleus. But then the characters do not agree, for my coat of the nucleus is not a cell, if by a cell is meant a simple vesicle not (disregarding the contents) again composed of a reticulated tissue. And yet the spore-cell of this observer must be my nucleus, since in this it is that the embryo finally makes its appearance, for he probably will not have meant the first cell of the embryo by this expression. Perhaps he has only examined dried ovules of *Isoëtes*, and the coat of the nucleus may have had a different shape in these. I have examined them only in the living condition, and in these the innermost coat was never a granulated simple cell.

In a note on the same page Mettenius reproaches me with having, in *Selaginella*, confounded the spore-cell with the innermost layer of the innermost coat of the spore, and at page 270 he says further, that he saw the spore in germination become gradually transformed into a sac composed of a single cell. From these words, my coat of the nucleus must be his spore-cell, and this becomes perfected into an independent sac (coat of the nucleus) only at a later stage, perhaps in germination. In *Selaginella*, I cannot now recollect, except in *Selaginella gracillima*, to have found such; in *Isoëtes lacustris* I have constantly met with it in the germinating spore. In any case it would be very interesting to have an accurate demonstration of the development of this cellular coat.

To avoid misconception, I observe, that by the *nucleus* I mean

* Linnæa, 1847, p. 269.

the third, innermost coat with all its contents, but that I distinguish the coat itself as the *coat of the nucleus*.

Regarding the contents, they are the same as those possessed by the ovules of *Selaginella*. They consist of a quantity of delicate, compact, transparent, at least colourless granules, which swim about in a fluid and give this a milky appearance. They are coloured brown by iodine, exactly as occurs in the *Selaginella*. Originally these cell-contents are but sparing in quantity; toward the beginning of the germination however they become so much increased that the whole of the cavity of the ovule is filled up (fig. 4).

3. *The Process of Germination.*

The part which the granular cell-contents play in the following process of formation of the embryo is of extraordinary importance, at the same time a very simple one. I showed formerly in my 'Essay on the Development of the Lycopodiaceæ*,' how this granular mass is constantly accompanied by a fluid which presents itself to the observer in the *form* of globules of oil. I pointed out moreover that these seeming globules of oil consist of a mucilaginous substance which furnishes the material for the subsequent formation of cells, and that these globules, coagulating in iodine and mineral acids, and above all being insoluble in æther, must not by any means be regarded as drops of oil, as has only too frequently happened; finally that they are the protoplasm of H. v. Mohl. All this holds good also of the contents of the ovule of *Isoëtes lacustris*. In the essay referred to I said further, that, mingled with this granular mass and the protoplasm, we always find some free cells which are coloured blue by iodine, which therefore are amylum-cells. All this is equally applicable to *Isoëtes*. But when I wrote that essay I was still ignorant of the connexion between the granular cell-contents, the amylum-cells and the protoplasm. This has only become clear to me, in the following manner, through the investigation of *Isoëtes*.

The granular matter is the element of the amylum-cell and the protoplasm. As I have mentioned above, every one of these granules is originally a perfectly compact globule. Such a globule, extremely small in its first stage, gradually increases in diameter, till, arrived at a certain limit, it presents a distinct cellular appearance. A cell of this kind then has the exact aspect of an amylum-cell, to which we readily see, beneath the microscope, that it very closely approaches in weight, since it always sinks to the bottom, and in texture, as it is lamellated, and looks almost as if perforated with a number of holes. In

* Ann. of Nat. Hist. Ser. 1. vol. xix.

fact, when it is acted on by iodine it also becomes coloured blue, and the result is that the said compact granule is transformed into an amylum-cell. This transition of the granule is actually very easy to trace when once we are aware of the connexion of the facts. All the intermediate stages between the original compact granule and the amylum-cell may readily be discriminated by the application of iodine. Moreover the granules become converted into starch at an extremely early epoch, before we can yet regard them as amylum-cells.

In my 'History of the Development of the Lycopodiaceæ' I mentioned a remarkable peculiarity of these amylum-cells, viz. that the blue colour produced by iodine very readily disappears again in certain amylum-cells, and that it may be restored just as readily by touching the cells, or often merely by rolling them backwards and forwards in the water; indeed, that one may often continue this alternation at one's pleasure for a long time. This peculiarity is equally characteristic of the amylum-cells of the ovule of *Isoëtes*. The phænomenon appears however only in the larger cells, such as may be recognised as amylum-cells even without the use of iodine. But neither here any more than in *Selaginella* have I succeeded in discovering the reason of this strange property.

With regard to the structure of the amylum-cell itself—this consists of more or less distinctly concentric layers deposited round a central nucleus which becomes coloured intensely blue by iodine (fig. 5). Several such dark groups often occur in one cell, the central nucleus being constantly present. In larger cells we may distinctly make out that these larger amylum-cells are distinct discoid bodies, convex on both faces (fig. 5 *a*). They frequently exhibit minute furrows, as is so often the case with starch-granules.

As soon as the granules are transformed into amylum they are in a condition to enter into new combinations with the elements of water. They swell up by the absorption of water, and then become decomposed into that fluid matter so often mentioned, which presents itself to the investigator in drops like oil. I have already stated in my 'History of the Development of *Chara**,' that I have directly observed this change, and I have there reported on it at length. As in that case, where the process may be traced more readily from the mere fact that the starch-cells are larger, they become softened in water, retaining their shape, until the whole of the contents comes into a fluid condition. Then they burst and the contents are scattered, always in the form of drops. I must therefore repeat here that the outermost layer of the

* Ann. of Nat. Hist. Ser. 1. vol. xvii. p. 258.

starch is always a denser membrane which may inclose the contents for a long time, and that therefore the process of solution proceeds from within outward. Exceedingly delicate granules are always found here, also, intermingled with the oil-like fluid (fig. 6). It is in like manner coloured brown by iodine.

In proportion as it was easy to observe this transformation of the starch-cells in the *Charæ,* since in them the whole contents of the nucleus consisted of starch, it was difficult to see the connexion between it and the primary granular mass of the ovule of the *Selaginellæ.* Therefore in the facts which I have published in my 'History of the Development of the Lycopodiaceæ' it must be equally understood, that the protoplasm is a product of the amylum-cells, and these latter of the granular mass.

By the time a considerable portion of the granular mass has become converted into protoplasm, the mass itself has so accumulated in the ovule that the latter is very much distended by it, and the mass has become so finely aggregated, that when isolated out of the ovule by careful preparation, it retains the shape of the ovule for some time as it lies in water beneath the microscope (fig. 4); and then *the first cell* is formed, in the interior of the mass, not very far from the apex of the ovule where it subsequently bursts, hanging immoveable but quite isolated in the mass. In order that it may constantly retain this position, it is extremely viscid and tenacious, so that it is usually uncommonly difficult to extract it in a perfect condition. It always presents an appearance as if it were fastened to the mass surrounding it by filaments.

It would be altogether useless to express any opinion as to the origin of this first cell. From my numerous investigations I do not believe in the possibility of discovering it in the first stage, simply for this reason: if it were before our eyes it could not be distinguished from the mucilaginous investing mass, since it must have the most deceptive resemblance to it. This reason therefore leads me to consider the discovery of the first perfect cell as a piece of good fortune, and this has only happened to me twice. Nevertheless this much is certain; the first cell is formed immediately out of the *protoplasm.* I beg my indulgent reader to form his own opinion as to the *mode* of origin of the cell as he may best conceive it.

4. *Formation of the Germ-plant up to the first rupture of the Ovule.*

When we have accomplished the always difficult operation of preparing the germ-cell free from its investing coats, we find it in the first instance perfectly round (fig. 7). I have neglected to measure it; but the relative size may readily be perceived from the figures by comparing the germ-cell, fig. 7 *a*, magnified fifty times with the ovule fig. 1, or fig. 14 also enlarged fifty diameters.

Under a power of 250 diameters it is distinctly seen that we have no longer to do with a simple cell, but with a mother-cell; in the fluid within it float some other cells in which the process of development has begun. Magnified 400 times the secondary (daughter)-cells are seen to consist of extremely delicate membranes, some of them also containing cytoblasts (Pl. II. fig. 7 *b*). The second germ-cell which I met with gives us some results with regard to the import of cytoblasts; the secondary cells are formed from them (fig. 8). Therefore in the first instance the mother-cell must contain merely a chaotic mass of cytoblastema, since fig. 8 speaks in favour of this, where most of the cell-contents consist of inorganized material for cells. Then free cytoblasts are produced out of this (fig. 8 *c*), and from these finally are developed the new cell-membrane, as is usual in the formation of the cell from cytoblasts, and the cytoblast remains lying on the wall (fig. 8 *d*).

When the whole of the cytoblastema of the mother-cell has been converted into secondary cells it forms a compact globular body (fig. 9 *a*), the cellular tissue of which is composed of many-sided cells compressed closely together, each containing its cytoblast (fig. 9 *b*). The mother-cell now acquires an oval shape. If acted on with iodine, it is rendered evident that the membrane of the mother-cell still incloses the whole tissue, for the latter contracts somewhat on account of the iodine, and the wall of the mother-cell thus becomes very distinctly visible as a colourless membrane enveloping the deep brown tissue (fig. 9 *c*). However, the presence of the mother-cell membrane is not a matter of long duration; apparently it lasts only up to this stage. Then it disappears, but whether by absorption or mechanical agency I have not observed. It may therefore be truly said that the germ is inclosed as in a sac by the mother-cell membrane up to a certain time. As it has often been asserted that this sac-like envelope of the original mother-membrane remains permanently inclosing the entire plant, I was unwilling to leave the above facts unmentioned, bearing as they do upon this opinion which has been so violently assailed by Schleiden.

Tracing the further course of the formation of the delicate germ, we next find the previously oval embryo extended more into a cylinder slightly curved on one side (fig. 10 *a*). Here, as in the immediately following stages, the cytoblast is still distinctly visible on the wall of every cell (fig. 10 *b*), till in the more independent germ it is gradually decomposed into chlorophylle.

The slight bend becomes continually more evident. A growth toward different sides visibly commences, showing itself in the altered form of the embryo; this is now elongated distinctly upward and downward (fig. 11). On the former prolongation nothing more is seen, except that the upper part of the embryo, *i. e.* that which subsequently breaks through the ovule, becomes attenuated. The alteration which occurs in the lower portion is more important. A growth toward two different sides manifests itself in very delicate outlines. On the one side (fig. 11 *a*) the embryo bulges out, on the other (*b*) it is attenuated, and the most external of the cells project spherically beyond the surface. Meanwhile a solitary cell in the concavity of the embryo has become so much enlarged that it protrudes like a globule beyond all the rest (fig. 11 *c*). *This is the first cell of the future so-called scale.* This exhibits over again all the phænomena presented by the mother-cell of the entire embryo. It contains like the latter an almost transparent, extremely fine granular cytoblastema, and is itself of an extraordinarily delicate structure. It is, moreover, situated in a *fold*, which is more clearly seen in the figures 12 and 13. *This fold is the future furrow or channel of the leaf.* When the observer succeeds in getting a view of this fold on the direct face, it is distinctly seen that the mother-cell of the scale stands upon another cell which serves for its foundation, and projects in like manner beyond the other cells forming the surface. I now leave the *cell of the scale*, that I may hereafter examine it more minutely in its relations as an independent organ,—the Scale.

While the *cell of the scale* up to the stage in fig. 13 has increased in size only and shown no apparent alteration in its interior, the double growth of the lower portion of the embryo has manifested itself in a more distinct manner; the projecting portion has become more evident, and the terminal cells forming spherical projections from the surface of the opposite side now have a horizontal direction.

This soon alters. The projecting portion which before only bellied out now becomes conical (fig. 12 *a*). Meanwhile it may be perceived that the lower surface of the embryo is becoming curved, at first slightly, afterwards in a very marked degree. Then that portion of the embryo on which the spherical, projecting cells occur turns upwards, out of its horizontal position and thus acquires one more vertical. By this means the spherical cells come to be placed on the upper surface (Pl. II. fig. 12 *d*). Here they come into immediate contact with the fold (fig. 13 *c*), the furrow of the future leaf, surround the *mother-cell of the scale* like a semicircular wall, *and form thus the foundation of the future leaf-sheath of the second leaf.*

This latter also has now commenced its course of development. It is the cell *c* in fig. 12, the cell *b* in fig. 13. It possesses the same characteristics, as mother-cell of the second leaf, as do the mother-cell of the whole embryo and that of the *scale*. It is a cell with extremely transparent contents and of most delicate consistence. The whole future germ-plant is now formed in the embryo.

1. *The first leaf* (fig. 12 *e*) ;
2. *The second leaf* (fig. 12 *f*) ;
3. *The scale of the first leaf* (fig. 12 *c*) ;
4. *The future root* (fig. 12 *b*) ;
5. *A reservoir, in which lies stored up the nutriment necessary to the embryo until it becomes capable of supporting itself independently* (fig. 12 *a*).

I will treat each of these organs separately in the following paragraphs, in order that I may be able to give a more summary account of them. It is very convenient also to break off here, since we have now arrived at the stage at which the embryo breaks through from the ovule. There are a few words to be added respecting this act.

The breaking through never happens all at once, but takes place gradually. First the *primine* bursts (fig. 14 *a*) ; this is soon followed by the opening of the *secundine* (fig. 14 *b*) ; the *coat of the nucleus* protrudes from these two as a conical process (fig. 14 *c*). The whole of the upper part of the ovule thus acquires a conical form.

The *primine* and *secundine* persist now in an unaltered condition, till at length, decaying, they fall away, bit by bit, from the coat of the nucleus, which itself in time meets with a similar fate. This now begins to expand considerably. This is caused solely by the expansion, not the multiplication, of its cells. The cellular tissue of the coat of the nucleus thus becomes quite loose in its texture. The papillary cells become less and less conspicuous ; all the cells are transparent (fig. 15).

The result of this is, that as the light penetrates through the expanding coat of the nucleus we see the first leaf, the tissue of which has by this time become green, showing as a little green cone through the upper transparent part of the coat of the nucleus.

If the entire germ is now extracted from the ovule, it is found exactly of such size that it reaches from the very top of the ovule to the bottom (fig. 15 *b*). This seems indeed a necessary condition, since in order to break through the ovule some pressure must be exerted upon the coat of the nucleus. This pressure can only be effected by the continual growth of the germ in the longitudinal direction, thus becoming longer than the coat of the nucleus, stretching it and finally breaking through it (fig. 15 *a*). I have found this condition regularly in all the ovules I have examined. The various organs only sketched out in slight outlines in figs. 12 and 13, are much more distinctly seen in such a germ at this stage. We may here distinguish clearly two strongly marked divisions, viz. 1, *the germinal body*; 2, *the first leaf*.

I have already used the term germinal body (Keimkörper) for the part morphologically corresponding in the germinating *Selaginellæ*, for that, namely, out of which developes the terminal bud of the stem and the root, which phænomena I shall discuss in the following section, since the immediately succeeding stages of the embryo, while breaking through, do not essentially differ from this in form.

[To be continued.]

IX.—*Notice of a deposit of Fossil* Diatomaceæ *in Aberdeenshire.* By George Dickie, M.D., Lecturer on Botany, King's College, Aberdeen*.

It is unnecessary to insist here upon the very general occurrence of silex in fresh and salt water, or the means by which it is dissolved and retained in solution; the very general distribution of Diatomaceous plants is a sufficient proof, if any such need be brought forward. It may be, that by some process like that called electrotype, the organisms in question are enabled to perpetuate their own beautiful forms, the impressions being taken in the purest transparent silex. The rapidity with which they are multiplied will account for the large deposits of fossil earth found in different parts of the world, and the indestructible nature of the mineral which they have the power of depositing in or upon their tissue enables us to recognize them long subsequently to the time when their vitality ceased.

In the month of March last, two different substances were sent to me for examination; they were described as having been found under a bed of clay at Premnay in the interior of Aberdeenshire. One of them consisted of small solid fragments of a dull white, the other had the form of a fine powder of a pure white. On examination it was found that the former consisted of decomposed felspar forming a kind of porcelain earth, the other had no small resemblance to some fossil earths with whose physical characters I was not unacquainted; accordingly, on submitting it to examination under the microscope, I found it to be entirely composed

* Read before the Botanical Society of Edinburgh 8th June, 1848.